

Patent
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REMARKS

Claims 24-41 are pending in the application.

Claims 24-26 and 27 are the only independent claims.

Applicant acknowledges with thanks the Examiner's indication that Claims 24-26 are allowable.

Claims 27-29, 32-36 and 38-41 were rejected under Section 103(a) as being unpatentable over US Patent 4,893,160 (Blanchard) in view of US Patent 5,216,275 (Chan).

Dependent Claims 30-31 and 37 were rejected as being unpatentable over Blanchard in view of Chan and US Patent 6,078,078 (Gardner).

Each of the rejections is respectfully traversed and reconsideration is requested.

Independent Claim 27 is directed to a power semiconductor device including a substrate of a first conductivity type, a voltage sustaining region disposed on the substrate, the voltage sustaining region including:

- an epitaxial layer having a first conductivity type;

- at least one terraced trench located in the epitaxial layer and having a plurality of portions that differ in width to define at least one annular ledge therebetween;

- at least one annular doped region having a dopant of a second conductivity type, the annular doped region being located in the epitaxial layer below and adjacent to the annular ledge;

- a filler material substantially filling the terraced trench; and

- at least one active region of the second conductivity disposed over the voltage sustaining region to define a junction therebetween.

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As acknowledged in the Action, Blanchard does not teach or suggest an “annular doped region”. As supported by the specification as filed, an annular region means “shaped like a ring”. Doped region 39 in Figure 4 of Blanchard does not have the shape of a ring, since there is no hole in the center.

The Action then takes the position that “Chen discloses a power semiconductor device in fig. 6 comprises a n-type substrate 4, a n-type epitaxial layer 5 a trench having either n or p-type conductivity region 6, col. 5 line 55” and that “at the time the invention was made, it would have been obvious...to use the doping teaching of Chen with Blanchard’s device, because it would have created a device with better on-voltage and breakdown voltage as taught by Chen in col. 1 lines 58-63”.

Applicant respectfully disagrees with this assertion. Specifically, Applicant submits that Blanchard prevents the reduction in breakdown voltage at the bottom corners of the gate trench by introducing a high concentration of dopant of the same conductivity type as the epitaxial layer. This high concentration reduces the mobility of the carriers, which results in a higher breakdown voltage.

Chen has alternating n-type and p-type regions as described in Figure 6 or at col. 5, line 55. However, the alternating columns form a composite buffer layer, and the order of the p-type and n-type layers *does not matter*.

Combining the two patents in the manner suggested to attempt to arrive at the claimed invention simply does not make sense, and would *not be obvious to one of ordinary skill in the art*, since Blanchard depends on carrier mobility reduction in a more highly doped region of the same conductivity type. Changing to the opposite conductivity type (P+) would not provide the same result, since no electrons would flow through a P+ doped region. Blanchard teaches *away from* such a modification.

For at least the foregoing reason, independent Claim 27 is believed to be clearly patentable over Blanchard and Chen, taken separately or in any permissible combination.

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Dependent Claims 28-41 are believed to be clearly patentable for at least the same reasons indicated above with respect to Claim 27, from which they depend, and even further distinguish over the cited references by reciting additional limitations.

For example, dependent Claim 30 further recites the limitation that said plurality of portions of the terraced trench includes at least three portions that differ in width from one another *to define at least two annular ledges* and said at least one annular doped region includes at least two annular doped regions.

Applicant submits that Blanchard has only *one annular terrace*, and only two different trench widths.

In addition, Gardner discloses a terraced gate, *not* a terraced region for obtaining islands of dopant for increasing breakdown voltage. The higher packing density noted in Gardner's Abstract ("[t]he V-shaped gate dielectric layer requires less horizontal substrate area, enabling higher packing density for a given substrate") relates to obtaining a greater effective source-to-drain distance in a *lateral* MOS transistor for a given source-to-drain spacing. There is no mention of a *vertical* structure.

Dependent Claim 32 recites that the epitaxial layer has a given thickness and the step of etching a first portion of the terraced trench by an amount substantially equal to $1/(x+1)$ of the given thickness, where x is equal to or greater than a prescribed number of annular doped regions to be formed in the voltage sustaining region.

The Action acknowledges that Blanchard fails to teach or suggest that "the etching is substantially equal to $1/(x+1)$ of the given thickness...", but takes the position that it "would have been obvious...because it has been held that where the general conditions of the claims are disclosed in the prior art, it is not inventive to discover the optimum or workable range by routine experimentation".

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Applicant respectfully disagrees, noting that Blanchard provides a structure with an improved breakdown voltage. The most efficient structure in Blanchard has the *only annular terrace* (or "step") a minimum height above the bottom of the trench to minimize the depth of the trench (see at least col. 4, lines 7-9 and 31-34). Applicant submits that there is in fact a disadvantage to having the terrace located too far above the bottom of the trench.

In addition, the trench in Blanchard contains the gate (see at least col. 5, lines 11-16). The bottom of the trench does not extend to just above the bottom of the epitaxial layer. In Applicant's device, the charge of the P-doped regions is spread relatively evenly from the top-to-bottom through the epitaxial layer. There is no such teaching in Blanchard.

Finally, Dependent Claim 37 recites that the surface area of the at least two annular ledges are substantially equal to one another. Applicant can find no such teaching or suggestion in Blanchard.

Since the Applicants have fully responded to each rejection set out in the Office Action, it is respectfully submitted that in regard to the above amendment and remarks that the pending application is patentable over the art of record and prompt review and issuance is accordingly requested. Should the Examiner be of the view that an interview would expedite consideration of this Amendment or of the application at large, request is made that the Examiner telephone the Applicants' undersigned attorney at (908) 518-7700 in order that any outstanding issues be resolved.

Respectfully submitted,


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